



## 1. Description

### 1.1. Project

Project Name	ui
Board Name	custom
Generated with:	STM32CubeMX 6.8.0
Date	04/29/2023

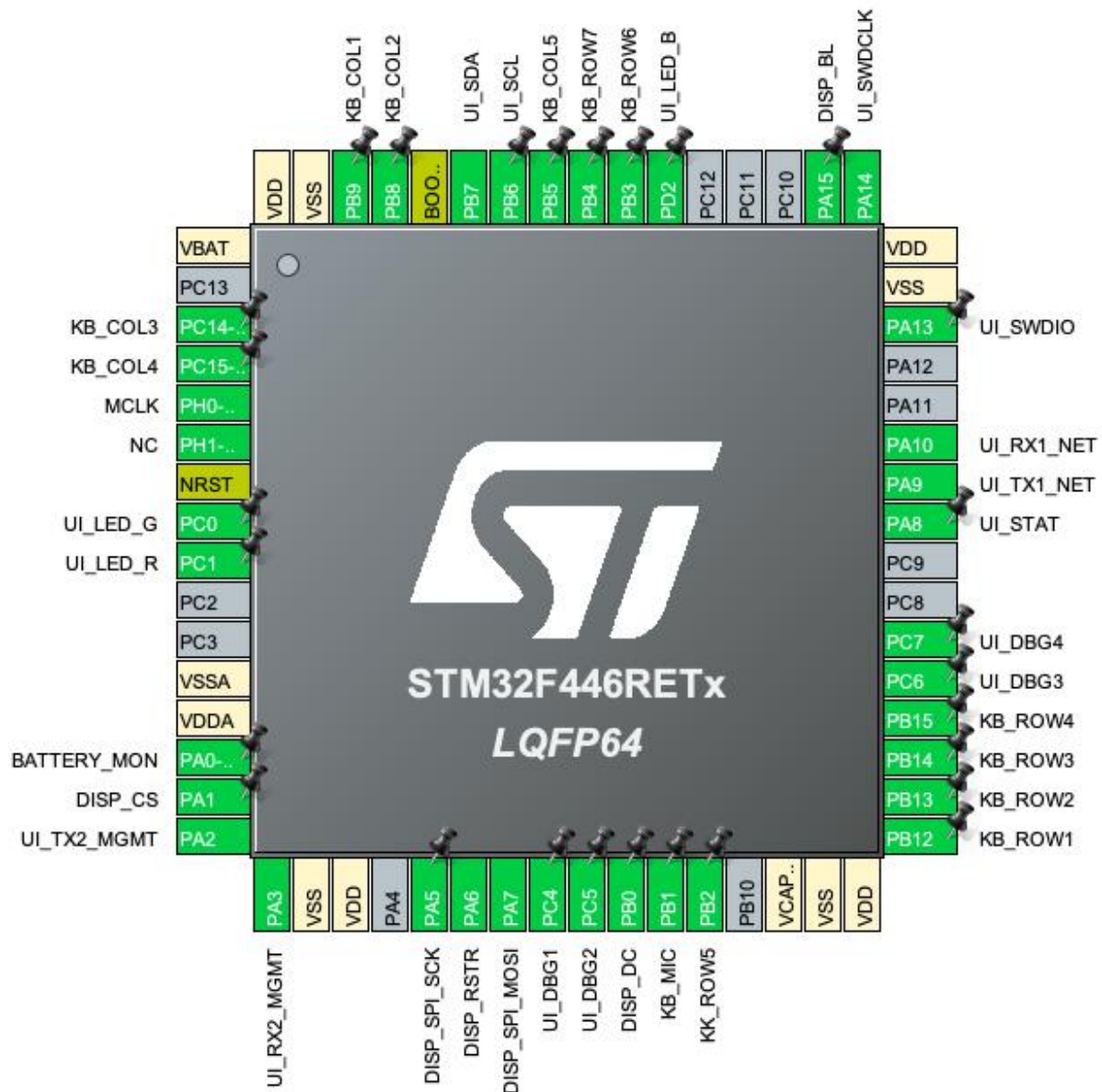
### 1.2. MCU

MCU Series	STM32F4
MCU Line	STM32F446
MCU name	STM32F446RETx
MCU Package	LQFP64
MCU Pin number	64

### 1.3. Core(s) information

Core(s)	Arm Cortex-M4
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## 2. Pinout Configuration



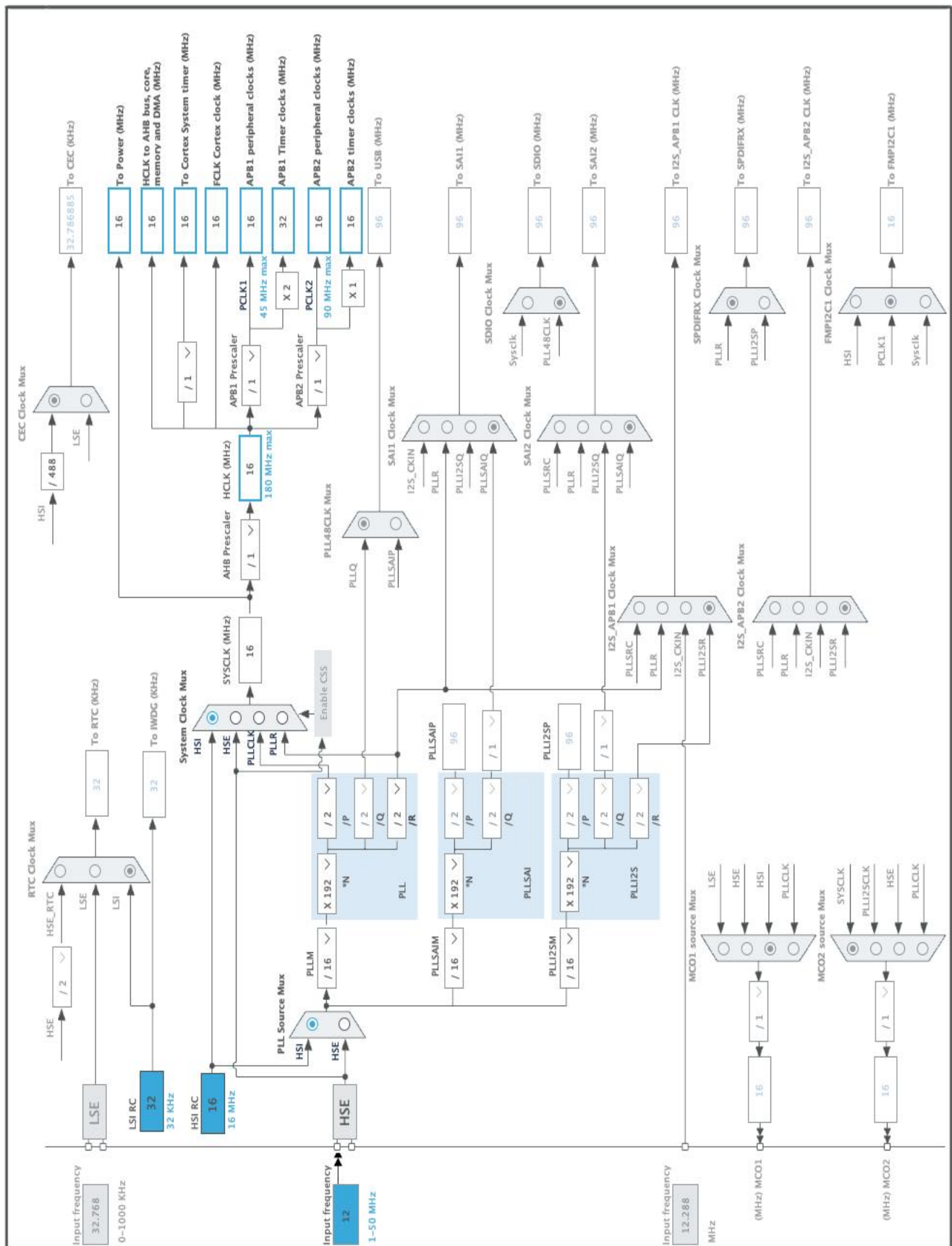
### 3. Pins Configuration

Pin Number LQFP64	Pin Name (function after reset)	Pin Type	Alternate Function(s)	Label
1	VBAT	Power		
3	PC14-OSC32_IN *	I/O	GPIO_Output	KB_COL3
4	PC15-OSC32_OUT *	I/O	GPIO_Output	KB_COL4
5	PH0-OSC_IN	I/O	RCC_OSC_IN	MCLK
6	PH1-OSC_OUT	I/O	RCC_OSC_OUT	NC
7	NRST	Reset		
8	PC0 *	I/O	GPIO_Output	UI_LED_G
9	PC1 *	I/O	GPIO_Output	UI_LED_R
12	VSSA	Power		
13	VDDA	Power		
14	PA0-WKUP	I/O	ADC1_IN0	BATTERY_MON
15	PA1 *	I/O	GPIO_Output	DISP_CS
16	PA2	I/O	USART2_TX	UI_TX2_MGMT
17	PA3	I/O	USART2_RX	UI_RX2_MGMT
18	VSS	Power		
19	VDD	Power		
21	PA5	I/O	SPI1_SCK	DISP_SPI_SCK
22	PA6	I/O	SPI1_MISO	DISP_RSTR
23	PA7	I/O	SPI1_MOSI	DISP_SPI_MOSI
24	PC4 *	I/O	GPIO_Output	UI_DBG1
25	PC5 *	I/O	GPIO_Output	UI_DBG2
26	PB0 *	I/O	GPIO_Output	DISP_DC
27	PB1	I/O	ADC2_IN9	KB_MIC
28	PB2 *	I/O	GPIO_Input	KK_ROW5
30	VCAP_1	Power		
31	VSS	Power		
32	VDD	Power		
33	PB12 *	I/O	GPIO_Input	KB_ROW1
34	PB13 *	I/O	GPIO_Input	KB_ROW2
35	PB14 *	I/O	GPIO_Input	KB_ROW3
36	PB15 *	I/O	GPIO_Input	KB_ROW4
37	PC6 *	I/O	GPIO_Output	UI_DBG3
38	PC7 *	I/O	GPIO_Output	UI_DBG4
41	PA8 *	I/O	GPIO_Output	UI_STAT
42	PA9	I/O	USART1_TX	UI_TX1_NET
43	PA10	I/O	USART1_RX	UI_RX1_NET

Pin Number LQFP64	Pin Name (function after reset)	Pin Type	Alternate Function(s)	Label
46	PA13	I/O	SYS_JTMS-SWDIO	UI_SWDIO
47	VSS	Power		
48	VDD	Power		
49	PA14	I/O	SYS_JTCK-SWCLK	UI_SWDCLK
50	PA15 *	I/O	GPIO_Output	DISP_BL
54	PD2 *	I/O	GPIO_Output	UI_LED_B
55	PB3 *	I/O	GPIO_Input	KB_ROW6
56	PB4 *	I/O	GPIO_Input	KB_ROW7
57	PB5 *	I/O	GPIO_Output	KB_COL5
58	PB6	I/O	I2C1_SCL	UI_SCL
59	PB7	I/O	I2C1_SDA	UI_SDA
60	BOOT0	Boot		
61	PB8 *	I/O	GPIO_Output	KB_COL2
62	PB9 *	I/O	GPIO_Output	KB_COL1
63	VSS	Power		
64	VDD	Power		

\* The pin is affected with an I/O function

## 4. Clock Tree Configuration



## 5. Software Project

### 5.1. Project Settings

Name	Value
Project Name	ui
Project Folder	/Users/fluffy/src/hactar/firmware/ui
Toolchain / IDE	EWARM V8.50
Firmware Package Name and Version	STM32Cube FW_F4 V1.27.1
Application Structure	Advanced
Generate Under Root	No
Do not generate the main()	No
Minimum Heap Size	0x200
Minimum Stack Size	0x400

### 5.2. Code Generation Settings

Name	Value
STM32Cube MCU packages and embedded software	Copy all used libraries into the project folder
Generate peripheral initialization as a pair of '.c/.h' files	No
Backup previously generated files when re-generating	No
Keep User Code when re-generating	Yes
Delete previously generated files when not re-generated	Yes
Set all free pins as analog (to optimize the power consumption)	No
Enable Full Assert	No

### 5.3. Advanced Settings - Generated Function Calls

Rank	Function Name	Peripheral Instance Name
1	SystemClock_Config	RCC
2	MX_GPIO_Init	GPIO
3	MX_ADC1_Init	ADC1
4	MX_ADC2_Init	ADC2
5	MX_I2C1_Init	I2C1
6	MX_SPI1_Init	SPI1
7	MX_USART1_UART_Init	USART1
8	MX_USART2_UART_Init	USART2

## 6. Power Consumption Calculator report

### 6.1. Microcontroller Selection

Series	STM32F4
Line	STM32F446
MCU	STM32F446RETx
Datasheet	DS10693_Rev6

### 6.2. Parameter Selection

Temperature	25
Vdd	3.3

### 6.3. Battery Selection

Battery	Li-SOCL2(A3400)
Capacity	3400.0 mAh
Self Discharge	0.08 %/month
Nominal Voltage	3.6 V
Max Cont Current	100.0 mA
Max Pulse Current	200.0 mA
Cells in series	1
Cells in parallel	1



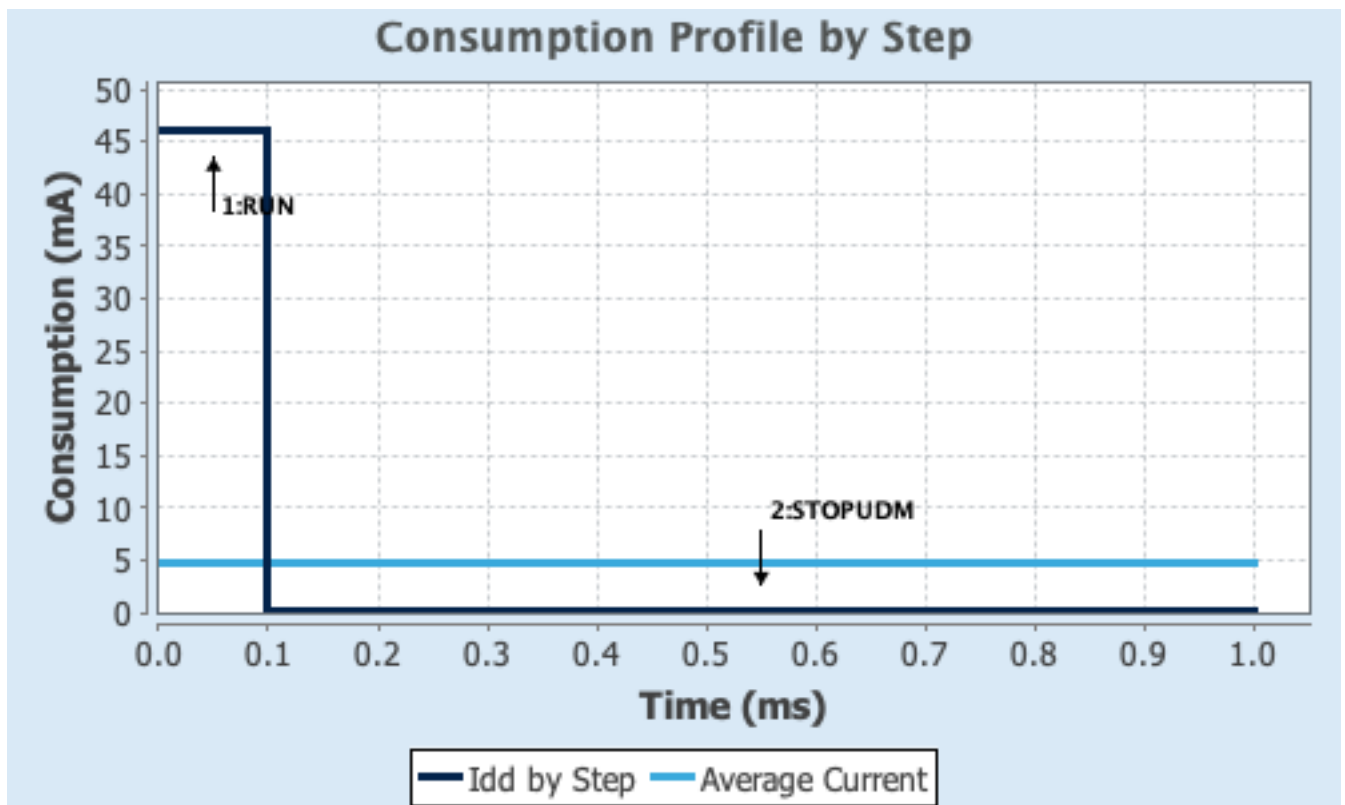
#### 6.4. Sequence

<b>Step</b>	Step1	Step2
<b>Mode</b>	RUN	STOP UDM (Under Drive)
<b>Vdd</b>	3.3	3.3
<b>Voltage Source</b>	Battery	Battery
<b>Range</b>	Scale1-High	No Scale
<b>Fetch Type</b>	RAM/FLASH/REGON/ART/P REFETCH	n/a
<b>CPU Frequency</b>	180 MHz	0 Hz
<b>Clock Configuration</b>	HSE PLL	Regulator LP Flash-PwrDwn
<b>Clock Source Frequency</b>	4 MHz	0 Hz
<b>Peripherals</b>		
<b>Additional Cons.</b>	0 mA	0 mA
<b>Average Current</b>	46 mA	55 $\mu$ A
<b>Duration</b>	0.1 ms	0.9 ms
<b>DMIPS</b>	225.0	0.0
<b>Ta Max</b>	98.02	104.99
<b>Category</b>	In DS Table	In DS Table

#### 6.5. Results

Sequence Time	1 ms	Average Current	4.65 mA
Battery Life	1 month	Average DMIPS	225.0 DMIPS

#### 6.6. Chart



## 7. Peripherals and Middlewares Configuration

### 7.1. ADC1

mode: IN0

#### 7.1.1. Parameter Settings:

##### ADCs\_Common\_Settings:

Mode Independent mode

##### ADC\_Settings:

Clock Prescaler PCLK2 divided by 4

Resolution 12 bits (15 ADC Clock cycles)

Data Alignment Right alignment

Scan Conversion Mode Disabled

Continuous Conversion Mode Disabled

Discontinuous Conversion Mode Disabled

DMA Continuous Requests Disabled

End Of Conversion Selection EOC flag at the end of single channel conversion

##### ADC\_Regular\_ConversionMode:

Number Of Conversion 1

External Trigger Conversion Source Regular Conversion launched by software

External Trigger Conversion Edge None

Rank 1

Channel Channel 0

Sampling Time 3 Cycles

##### ADC\_Injected\_ConversionMode:

Number Of Conversions 0

##### WatchDog:

Enable Analog WatchDog Mode false

### 7.2. ADC2

mode: IN9

#### 7.2.1. Parameter Settings:

##### ADCs\_Common\_Settings:

Mode Independent mode

##### ADC\_Settings:

Clock Prescaler PCLK2 divided by 4

Resolution 12 bits (15 ADC Clock cycles)

Data Alignment Right alignment

Scan Conversion Mode	Disabled
Continuous Conversion Mode	Disabled
Discontinuous Conversion Mode	Disabled
DMA Continuous Requests	Disabled
End Of Conversion Selection	EOC flag at the end of single channel conversion

**ADC\_Regular\_ConversionMode:**

Number Of Conversion	1
External Trigger Conversion Source	Regular Conversion launched by software
External Trigger Conversion Edge	None
Rank	1
Channel	Channel 9
Sampling Time	3 Cycles

**ADC\_Injected\_ConversionMode:**

Number Of Conversions	0
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**WatchDog:**

Enable Analog WatchDog Mode	false
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## 7.3. I2C1

### I2C: I2C

#### 7.3.1. Parameter Settings:

**Master Features:**

I2C Speed Mode	Standard Mode
I2C Clock Speed (Hz)	100000

**Slave Features:**

Clock No Stretch Mode	Disabled
Primary Address Length selection	7-bit
Dual Address Acknowledged	Disabled
Primary slave address	0
General Call address detection	Disabled

## 7.4. RCC

### High Speed Clock (HSE): BYPASS Clock Source

#### 7.4.1. Parameter Settings:

**System Parameters:**

VDD voltage (V)	3.3
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Instruction Cache	Enabled
Prefetch Buffer	Enabled
Data Cache	Enabled
Flash Latency(WS)	2 WS (3 CPU cycle)

**RCC Parameters:**

HSI Calibration Value	16
TIM Prescaler Selection	Disabled
HSE Startup Timeout Value (ms)	100
LSE Startup Timeout Value (ms)	5000

**Power Parameters:**

Power Regulator Voltage Scale	Power Regulator Voltage Scale 3
Power Over Drive	Disabled

## 7.5. SPI1

### Mode: Full-Duplex Master

#### 7.5.1. Parameter Settings:

**Basic Parameters:**

Frame Format	Motorola
Data Size	8 Bits
First Bit	MSB First

**Clock Parameters:**

Prescaler (for Baud Rate)	2
Baud Rate	<b>42.0 MBits/s *</b>
Clock Polarity (CPOL)	Low
Clock Phase (CPHA)	1 Edge

**Advanced Parameters:**

CRC Calculation	Disabled
NSS Signal Type	Software

## 7.6. SYS

### Debug: Serial Wire

#### Timebase Source: SysTick

## 7.7. USART1

### Mode: Asynchronous

### 7.7.1. Parameter Settings:

#### **Basic Parameters:**

Baud Rate	115200
Word Length	8 Bits (including Parity)
Parity	None
Stop Bits	1

#### **Advanced Parameters:**

Data Direction	Receive and Transmit
Over Sampling	16 Samples

## **7.8. USART2**

### **Mode: Asynchronous**

### 7.8.1. Parameter Settings:

#### **Basic Parameters:**

Baud Rate	115200
Word Length	8 Bits (including Parity)
Parity	None
Stop Bits	1

#### **Advanced Parameters:**

Data Direction	Receive and Transmit
Over Sampling	16 Samples

\* User modified value

## 8. System Configuration

### 8.1. GPIO configuration

IP	Pin	Signal	GPIO mode	GPIO pull/up pull down	Max Speed	User Label
ADC1	PA0-WKUP	ADC1_IN0	Analog mode	No pull-up and no pull-down	n/a	BATTERY_MON
ADC2	PB1	ADC2_IN9	Analog mode	No pull-up and no pull-down	n/a	KB_MIC
I2C1	PB6	I2C1_SCL	Alternate Function Open Drain	No pull-up and no pull-down	Very High *	UI_SCL
	PB7	I2C1_SDA	Alternate Function Open Drain	No pull-up and no pull-down	Very High *	UI_SDA
RCC	PH0-OSC_IN	RCC_OSC_IN	n/a	n/a	n/a	MCLK
	PH1-OSC_OUT	RCC_OSC_OUT	n/a	n/a	n/a	NC
SPI1	PA5	SPI1_SCK	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	DISP_SPI_SCK
	PA6	SPI1_MISO	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	DISP_RSTR
	PA7	SPI1_MOSI	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	DISP_SPI_MOSI
SYS	PA13	SYS_JTMS-SWDIO	n/a	n/a	n/a	UI_SWDIO
	PA14	SYS_JTCK-SWCLK	n/a	n/a	n/a	UI_SWDCCLK
USART1	PA9	USART1_TX	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	UI_TX1_NET
	PA10	USART1_RX	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	UI_RX1_NET
USART2	PA2	USART2_TX	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	UI_TX2_MGMT
	PA3	USART2_RX	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	UI_RX2_MGMT
GPIO	PC14-OSC32_IN	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	KB_COL3
	PC15-OSC32_OUT	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	KB_COL4
	PC0	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	UI_LED_G
	PC1	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	UI_LED_R
	PA1	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	DISP_CS

IP	Pin	Signal	GPIO mode	GPIO pull/up pull down	Max Speed	User Label
	PC4	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	UI_DBG1
	PC5	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	UI_DBG2
	PB0	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	DISP_DC
	PB2	GPIO_Input	Input mode	No pull-up and no pull-down	n/a	KK_ROW5
	PB12	GPIO_Input	Input mode	No pull-up and no pull-down	n/a	KB_ROW1
	PB13	GPIO_Input	Input mode	No pull-up and no pull-down	n/a	KB_ROW2
	PB14	GPIO_Input	Input mode	No pull-up and no pull-down	n/a	KB_ROW3
	PB15	GPIO_Input	Input mode	No pull-up and no pull-down	n/a	KB_ROW4
	PC6	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	UI_DBG3
	PC7	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	UI_DBG4
	PA8	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	UI_STAT
	PA15	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	DISP_BL
	PD2	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	UI_LED_B
	PB3	GPIO_Input	Input mode	No pull-up and no pull-down	n/a	KB_ROW6
	PB4	GPIO_Input	Input mode	No pull-up and no pull-down	n/a	KB_ROW7
	PB5	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	KB_COL5
	PB8	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	KB_COL2
	PB9	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	KB_COL1

## 8.2. DMA configuration

nothing configured in DMA service



### 8.3. NVIC configuration

#### 8.3.1. NVIC

Interrupt Table	Enable	Preenmption Priority	SubPriority
Non maskable interrupt	true	0	0
Hard fault interrupt	true	0	0
Memory management fault	true	0	0
Pre-fetch fault, memory access fault	true	0	0
Undefined instruction or illegal state	true	0	0
System service call via SWI instruction	true	0	0
Debug monitor	true	0	0
Pendable request for system service	true	0	0
System tick timer	true	15	0
PVD interrupt through EXTI line 16	unused		
Flash global interrupt	unused		
RCC global interrupt	unused		
ADC1, ADC2 and ADC3 interrupts	unused		
I2C1 event interrupt	unused		
I2C1 error interrupt	unused		
SPI1 global interrupt	unused		
USART1 global interrupt	unused		
USART2 global interrupt	unused		
FPU global interrupt	unused		

#### 8.3.2. NVIC Code generation

Enabled interrupt Table	Select for init sequence ordering	Generate IRQ handler	Call HAL handler
Non maskable interrupt	false	true	false
Hard fault interrupt	false	true	false
Memory management fault	false	true	false
Pre-fetch fault, memory access fault	false	true	false
Undefined instruction or illegal state	false	true	false
System service call via SWI instruction	false	true	false
Debug monitor	false	true	false
Pendable request for system service	false	true	false
System tick timer	false	true	true

\* User modified value

## 9. System Views

### 9.1. Category view

#### 9.1.1. Current

Middleware					

System Core	Analog	Timers	Connectivity	Multimedia	Computing
DMA	ADC1 ✓		I2C1 ✓		
GPIO ✓	ADC2 ✓		SPI1 ✓		
NVIC ✓			USART1 ✓		
RCC ✓			USART2 ✓		
SYS ✓					

## 10. Docs & Resources

Type	Link
BSDL files	<a href="https://www.st.com/resource/en/bsdl_model/stm32f446_bsd.zip">https://www.st.com/resource/en/bsdl_model/stm32f446_bsd.zip</a>
IBIS models	<a href="https://www.st.com/resource/en/ibis_model/stm32f446_ibis.zip">https://www.st.com/resource/en/ibis_model/stm32f446_ibis.zip</a>
System View Description	<a href="https://www.st.com/resource/en/svd/stm32f4_svd.zip">https://www.st.com/resource/en/svd/stm32f4_svd.zip</a>
BSDL files	<a href="https://www.st.com/resource/en/bsdl_model/stm32f446_bsd.zip">https://www.st.com/resource/en/bsdl_model/stm32f446_bsd.zip</a>
IBIS models	<a href="https://www.st.com/resource/en/ibis_model/stm32f446_ibis.zip">https://www.st.com/resource/en/ibis_model/stm32f446_ibis.zip</a>
System View Description	<a href="https://www.st.com/resource/en/svd/stm32f4_svd.zip">https://www.st.com/resource/en/svd/stm32f4_svd.zip</a>
Presentations	<a href="https://www.st.com/resource/en/product_presentation/stm32-stm8_embedded_software_solutions.pdf">https://www.st.com/resource/en/product_presentation/stm32-stm8_embedded_software_solutions.pdf</a>
Presentations	<a href="https://www.st.com/resource/en/product_presentation/stm32_eval-tools_portfolio.pdf">https://www.st.com/resource/en/product_presentation/stm32_eval-tools_portfolio.pdf</a>
Presentations	<a href="https://www.st.com/resource/en/product_presentation/stm32_stm8_functional-safety-packages.pdf">https://www.st.com/resource/en/product_presentation/stm32_stm8_functional-safety-packages.pdf</a>
Presentations	<a href="https://www.st.com/resource/en/product_presentation/stm32-stm8_software_development_tools.pdf">https://www.st.com/resource/en/product_presentation/stm32-stm8_software_development_tools.pdf</a>
Training Material	<a href="https://www.st.com/resource/en/sales_guide/sg_sc2154.pdf">https://www.st.com/resource/en/sales_guide/sg_sc2154.pdf</a>
Flyers	<a href="https://www.st.com/resource/en/flyer/flstm32nucleo.pdf">https://www.st.com/resource/en/flyer/flstm32nucleo.pdf</a>
Flyers	<a href="https://www.st.com/resource/en/flyer/flstmcsuite.pdf">https://www.st.com/resource/en/flyer/flstmcsuite.pdf</a>
Flyers	<a href="https://www.st.com/resource/en/flyer/flstm32trust.pdf">https://www.st.com/resource/en/flyer/flstm32trust.pdf</a>
Product Certifications	<a href="https://www.st.com/resource/en/certification_document/stm32_authentication_can.pdf">https://www.st.com/resource/en/certification_document/stm32_authentication_can.pdf</a>
Application Notes	<a href="https://www.st.com/resource/en/application_note/an1181-electrostatic-discharge-sensitivity-measurement-stmicroelectronics.pdf">https://www.st.com/resource/en/application_note/an1181-electrostatic-discharge-sensitivity-measurement-stmicroelectronics.pdf</a>
Application Notes	<a href="https://www.st.com/resource/en/application_note/an1709-emc-design-guide-for-stm8-stm32-and-legacy-mcus-stmicroelectronics.pdf">https://www.st.com/resource/en/application_note/an1709-emc-design-guide-for-stm8-stm32-and-legacy-mcus-stmicroelectronics.pdf</a>
Application Notes	<a href="https://www.st.com/resource/en/application_note/an2606-stm32-microcontroller-system-memory-boot-mode-stmicroelectronics.pdf">https://www.st.com/resource/en/application_note/an2606-stm32-microcontroller-system-memory-boot-mode-stmicroelectronics.pdf</a>

- Application Notes [https://www.st.com/resource/en/application\\_note/an2639-soldering-recommendations-and-package-information-for-leadfree-ecopack-mcus-and-mpus-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an2639-soldering-recommendations-and-package-information-for-leadfree-ecopack-mcus-and-mpus-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an2834-how-to-get-the-best-adc-accuracy-in-stm32-microcontrollers-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an2834-how-to-get-the-best-adc-accuracy-in-stm32-microcontrollers-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an2867-oscillator-design-guide-for-stm8afals-stm32-mcus-and-mpus-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an2867-oscillator-design-guide-for-stm8afals-stm32-mcus-and-mpus-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an2945-stm8s-and-stm32-mcus-a-consistent-832bit-product-line-for-painless-migration-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an2945-stm8s-and-stm32-mcus-a-consistent-832bit-product-line-for-painless-migration-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an3070-managing-the-driver-enable-signal-for-rs485-and-iolink-communications-with-the-stm32s-usart-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an3070-managing-the-driver-enable-signal-for-rs485-and-iolink-communications-with-the-stm32s-usart-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an3126-audio-and-waveform-generation-using-the-dac-in-stm32-products-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an3126-audio-and-waveform-generation-using-the-dac-in-stm32-products-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an3154-can-protocol-used-in-the-stm32-bootloader-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an3154-can-protocol-used-in-the-stm32-bootloader-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an3155-usart-protocol-used-in-the-stm32-bootloader-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an3155-usart-protocol-used-in-the-stm32-bootloader-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an3156-usb-dfu-protocol-used-in-the-stm32-bootloader-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an3156-usb-dfu-protocol-used-in-the-stm32-bootloader-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an3364-migration-and-compatibility-guidelines-for-stm32-microcontroller-applications-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an3364-migration-and-compatibility-guidelines-for-stm32-microcontroller-applications-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an3997-audio-playback-and-recording-using-the-stm32f4discovery-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an3997-audio-playback-and-recording-using-the-stm32f4discovery-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an3998-pdm-audio-software-decoding-on-stm32-microcontrollers-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an3998-pdm-audio-software-decoding-on-stm32-microcontrollers-stmicroelectronics.pdf)
- Application Notes [https://www.st.com/resource/en/application\\_note/an4013-stm32-crossseries-timer-overview-stmicroelectronics.pdf](https://www.st.com/resource/en/application_note/an4013-stm32-crossseries-timer-overview-stmicroelectronics.pdf)
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